A NEW SPECIES OF *LIATRIS* (ASTERACEAE) FROM THE CAROLINA SANDHILLS[1]

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ABSTRACT

Liatris regimontis (Small) Schumann has been regarded as a species widely distributed in the western Piedmont and adjacent provinces of Virginia, North Carolina, South Carolina, and Georgia. Principal components analyses (PCA) show that the holotype and an isotype of *L. regimontis* from the western Piedmont of NC are close morphological approximates of the holotype of *L. graminifolia* var. *smallii* (Britton) Fern. & Griscom from the mountains of VA and that the two types of the former species fall well within the range of morphological variability described by a sample of the latter variety. It is concluded that *L. graminifolia* var. *smallii* and the types of *L. regimontis* represent the same taxon. PCA and cluster analyses show that specimens from the Fall-line sandhills of North and South Carolina previously determined by other investigators as *L. regimontis* are morphologically discontinuous with material from other portions of the species range, including the holotype and isotype, and with collections of *L. graminifolia* var. *smallii*. This distinct sandhills plant is here described as a new species, *Liatris cokeri* Pyne & Stucky. In a geographical zone in the Coastal Plain of the Carolinas, where the ranges of *L. cokeri* and *L. graminifolia* become contiguous, specimens that are morphologically intermediate between the two species have been collected.

Liatris regimontis (Small) Schumann ha sido considerada una especie ampliamente distribuida en la parte occidental del Piedmont y en provincias próximas de los estados de Virginia, Carolina del Norte, Carolina del Sur, y Georgia. Los análisis de componentes principales (PCA) muestran que el holotipo y un isotipo de *L. regimontis* de la parte occidental del Piedmont en Carolina del Norte son próximas en morfología al holotipo de *L. graminifolia* var. *smallii* (Britt.) Fern. & Griscom de las montañas de Virginia, y que los dos tipos de la primera especie se hallan dentre del rango de variabilidad morfológica circumscrita por un muestréo de la seguna variedad. Se concluye que *L. graminifolia* var. *smallii* y los tipos de *L. regimontis* representan el mismo taxon. PCA y análisis de grupos ("cluster analysis") muestran que especimenes del area Fall-line sandhills en Carolina del Norte y del Sur, anteriormente identificados como *L. regimontis* por otros investigatores, son morfológicamente discontinuos con colectas de otras areas de la distribución de la especie, incluyendo el holotipo e isotipo, y con colectas de *L. graminifolia* var. *smallii*. Esta planta distinta de las colinas arenosas se describe aquí como una especie nueva, *Liatris cokeri* Pyne & Stucky. En una zona geografica donde la distribución de *L. cokeri* y de *L. graminifolia* son contíguas, especimenes que son morfológicamente intermedios entre las dos especies han sido colectados.

[1]Paper No. 12469 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27696 – 7601.

INTRODUCTION

In preparation for a taxonomic study of *Liatris* Series Graminifoliae, herbarium material (GH, NCSC, NCU, NY, USCH) of the five species in the series was examined. A problem with the circumscription of *L. regimontis* (Small) Schumann was revealed. Most treatments (Godfrey 1948; Fernald 1950; Cronquist 1952, 1963, 1980) follow Gaiser's (1946) by recognizing *L. regimontis* as a widely distributed species (Atlantic Coastal Plain to western Piedmont, Va to Ga) which inhabits a variety of substrates. In contrast Ahles (in Radford et al. 1968) applies this name to plants only of the Carolina Fall-line sandhills as defined by Duke (1961). The plants from outside the sandhills region included in *L. regimontis* by the previous workers are included in *L. graminifolia* by Ahles.

Small (1898) based the original concept of *Lacinaria regimontis* [= *Liatris regimontis* (Small) Schumann] on his collections from King's Mountain, Cleveland County, NC. Alexander (in Small 1933) defines the range of this species as "outliers of the Blue Ridge in the Piedmont, also in adjacent provinces." It is, therefore, surprising that the majority of collections to which the name *Liatris regimontis* has been applied are plants from the Fall-line sandhills. If the species concept of Gaiser and subsequent workers is followed, then *L. regimontis* appears to include two distinct morphological types; one which occurs throughout the Fall-line sandhills and another which occurs in the western Piedmont of Virginia and North Carolina and the Piedmont and Coastal Plain of South Carolina and Georgia. If the species concept of Ahles is followed, then a morphologically more homogeneous species results, but this concept excludes the Cleveland County, NC type location from the species range. If, in fact, *L. regimontis sensu lato* comprises two morphological variants deserving of recognition, then the one from the sandhills must bear a name other than *L. regimontis*.

Most collections compatible with the type material of *Liatris regimontis* have previously been determined as *L. graminifolia* Willd. var. *smallii* (Britton) Fern. & Griscom. Cronquist (1980) lists this variety in synonymy under *L. regimontis*. Numerous collections from the Fall-line sandhills have been determined by other investigators as *L. regimontis* despite their morphological incompatibility with the type material.

Since the present study of *Liatris regimontis* is based largely on specimens determined as *L. graminifolia* var. *smallii*, it is necessary to demonstrate that the types of the two taxa are compatible and that these two names apply to the same plant. Accordingly, the purposes of this study are to (1) demonstrate that the names *Liatris regimontis* and *L. graminifolia* var. *smallii* apply to the same plant, (2) determine if material from the Fall-line sandhills is morphologically distinct from material of the Piedmont and

Coastal Plain portion of the range of *L. regimontis*, and (3) present the most appropriate taxonomic treatment. (Henceforth in this paper, unless otherwise indicated, the element of the Fall-line sandhills will be called the "sandhills plant;" the more widely distributed element of a western Piedmont and Coastal Plain distribution will be called *Liatris graminifolia* var. *smallii*).

MATERIALS AND METHODS

Collections of *Liatris regimontis* and *L. graminifolia* var. *smallii* obtained from G, NCSC, NCU, NY, and USCH were examined.

LIATRIS REGIMONTIS - L. GRAMINIFOLIA VAR. SMALLII COMPARISON — Data for principal components analysis (PCA) was obtained from the holotype and an isotype specimen of *L. regimontis* [NORTH CAROLINA. Cleveland Co.: King's Mt., 27–30 Aug 1894, *J. K. Small s.n.* (HOLOTYPE: NY!; ISOTYPE: NY!)], the holotype of *L. graminifolia* var. *smallii* [VIRGINIA. Smyth Co.: along Dickey Creek on Iron Mtn., 2900,' 8 Aug 1892, *J. K. Small s.n.* (HOLOTYPE:NY!)], 22 specimens of *Liatris graminifolia* var. *smallii* from western Piedmont sites, 16 specimens of *L. graminifolia* var. *smallii* from Coastal Plain sites, and five specimens of *L. graminifolia* var. *graminifolia* (Table 1). The last taxon was included to provide outgroup comparison.

States of seventeen characters (Table 2) determined for each specimen constituted data set A. The OTU (specimen) X character matrix was standardized by characters and a character correlation matrix was derived from the standardized matrix. PCA was performed on this correlation matrix.

LIATRIS REGIMONTIS TYPE SPECIMENS - SANDHILLS PLANT COMPARISON — Univariate comparison of the holotype and an isotype of *Liatris regimontis* (see above) and 65 specimens of the sandhills plant was performed. Characters utilized were among those mentioned in Small's type description of *Lacinaria regimontis* (1898).

LIATRIS GRAMINIFOLIA VAR. SMALLII - SANDHILLS PLANT COMPARISON — A data set was compiled for 25 sandhills plant specimens, 22 *L. graminifolia* var. *smallii* specimens from western Piedmont sites, 16 *L. graminifolia* var. *smallii* specimens from Coastal Plain sites, the holotype of *L. graminifolia* var. *smallii*, the holotype and isotype of *L. regimontis*, and 5 specimens of *L. graminifolia* var. *graminifolia* included as outgroup representatives (Table 1). The full data set comprising 17 characters, data set B, and a subset of data comprising six characters (Table 2,), data set C, were each subjected to PCA which was performed as described above. Data set C comprised quantitative expressions of those characters included in the

univariate comparison. Cluster analyses were performed on data sets B and C. Taxonomic resemblance between OTU's was measured using the chord distance equation (Pielou 1984) and Gower's coefficient of similarity (Gower 1971). The resulting distance matrices were subjected to UPGMA clustering (Sneath and Sokal 1973). Results for those analyses utilizing Gower's coefficient will be presented as phenograms.

TABLE 1. Group designation, geographic origin, collection number, and OTU number for specimens included in this study.

Group Designation[a]	Geographic origin (Co./State)	Collection No.	OTU
L. graminifolia			
var. *smallii*, WP[b]	Avery/NC	*Ahles & Duke 49602*	38
	Cleveland/NC[c]	*Small s.n.*	59
	Cleveland/NC[d]	*Small s.n.*	18
	Gaston/NC	*Fox 5426*	39
	Iredell/NC	*Veerhoff s.n.*	44
	Lincoln/NC	*Bell 15349*	42
	McDowell/NC	*Beaman 64*	47
	McDowell/NC	*Beaman 210*	48
	McDowell/NC	*Beaman 220*	34
	McDowell/NC	*Bell 4477*	32
	Mecklenberg/NC	*Ahles & Duke 50000*	45
	Rutherford/NC	*Fox 5273*	37
	Stokes/NC	*Godfrey & Fox 48575*	51
	Stokes/NC	*Radford 41403*	31
	Surry/NC	*Godfrey & Fox 50181*	35
	Transylvania/NC	*Bannister & Anderson 702*	52
	Transylvania/NC	*Cooper 2373*	33
	Transylvania/NC	*Godfrey & Fox 49919*	41
	Transylvania/NC	*Hardin 2222*	50
	Oconee/SC	*Powell & Patton s.n.*	18
	Oconee/SC	*Radford 17765*	49
	Pickens/SC	*Radford 16457*	36
	Union/SC	*Bell 10616*	46
	York/SC	*Ahles 34488*	43
	Smythe/VA[e]	*Small s.n.*	60
L. graminifolia			
var. *smallii*, CP[b]			
	Elbert/GA	*Cole 1384*	75
	Hart/GA	*McCarthy s.n.*	67
	Allendale/SC	*Bell 5220*	68
	Bamberg/SC	*Ahles 37615*	74
	Bamberg/SC	*Ahles 37634*	72
	Berkeley/SC	*Ahles 35525*	79
	Calhoun/SC	*Ahles 35362*	70
	Charleston/SC	*Ahles & Haesloop 38132*	80
	Colleton/SC	*Rayner 1840*	78
	Florence/SC	*Bartlett 2856*	69
	Hampton/SC	*Ahles & Bell 18274*	73

TABLE 1 (continued)

	Jasper/SC	*Bell 5117*	76
	Lexington/SC	*Hutto 199*	71
	Orangeburg/SC	*Ables 34949*	66
	Richland/SC	*Godfrey 50747*	40
	Williamsburg/SC	*Radford 3115*	77
Sandhills	Cumberland/NC	*Ables & Leisner 33484*	14
	Harnett/NC	*Fox & Whitford 1836*	9
	Harnett/NC	*Rock 661*	27
	Hoke/NC	*Ables 36348*	57
	Hoke/NC	*Ables 36491*	58
	Hoke/NC	*Duke R-3289*	6
	Hoke/NC	*Godfrey & Fox 50551*	54
	Montgomery/NC	*Radford 19636*	14
	Moore/NC	*Godfrey 50098*	56
	Moore/NC	*Duke Q-3355*	8
	Moore/NC	*Wicken s.n.*	46
	Richmond/NC	*Freeman 56768*	1
	Richmond/NC	*Radford 19324*	29
	Robeson/NC	*Fox 5568*	10
	Scotland/NC	*Duke 2507*	4
	Scotland/NC	*Duke 3240*	3
	Wayne/NC	*Bruton 406*	2
	Chesterfield/SC	*Bradley & Sears 3505*	30
	Chesterfield/SC	*Duke & Ables 2200*	5
	Darlington/SC	*Coker s.n.*	28
	Darlington/SC	*Smith 1019*	13
	Dillon/SC	*Ables 37096*	12
	Kershaw/SC	*Duke 2313*	16
	Kershaw/SC	*Duke Q-2936*	53
	Marlboro/SC	*Duke Q-3110*	7
Intermediate	Bladen/NC	*Ables 37866*	23
	Bladen/NC	*Crutchfield 5591*	25
	Columbus/NC	*Bell 15837*	22
	Columbus/NC	*Bell 15944*	21
	Cumberland/NC	*Ables 36528*	20
	Johnston/NC	*Godfrey & Fox 48703*	11
	Robeson/NC	*Britt 2583*	26
	Wayne/NC	*Radford 28836*	19
	Horry/SC	*Duke 0199*	24
L. graminifolia var. *graminifolia*	Chatham/NC	*Massey & Massey 2979*	65
	Pender/NC	*Ables 36171*	64
	Union/NC	*Ables 34012*	62
	Warren/NC	*Bozeman & Radford 11549*	61
	Washington/NC	*Radford 42375*	63

[a]Group designation at initiation of study.
[b]Western Piedmont.
[c]Holotype of *L. regimontis* (Small) Schumann.
[d]Isotype of *L. regimontis* (Small) Schumann
[e]Holotype of *L. graminifolia* var. *smallii* (Britton) Fern. & Grisc.
[f]Coastal Plain.

Nine herbarium specimens appeared morphologically intermediate (Table 1) and could not be designated with confidence as either *Liatris graminifolia* var. *smallii* or the sandhills plant. Data from these specimens added to data sets B and C yielded data sets D and E, respectively. PCA was performed on both D and E.

RESULTS

LIATRIS REGIMONTIS - L. GRAMINIFOLIA VAR. SMALLII COMPARISON — The first axis of the PCA explained 24.1% of the data variation. The characters loading heavily on this axis pertained to head and flower size and head density along the inflorescence axis (Table 3). The second axis explained 16.0% of the data variation and was interpreted primarily as a phyllary shape axis (Table 3). Although somewhat distinguished by the second PCA axis, the PCA scores of the type specimens (OTU's 18, 59, 60) were relatively compatible (Fig. 1). In relation to the total array of PCA scores, the scores for the types were not centrally located; however, they were clearly not disparate. Although there was not a discernable discontinuity between PCA scores for western Piedmont and Coastal Plain

TABLE 2. Characters and character states used in the multivariate study.

PEDICEL:	1.	Pedicel length (mm)
HEADS:	2.	Number/3 cm inflorescence axis[a]
	3.	Orientation. 1, strongly divergent; 2, weakly divergent 3, strongly ascending
INVOLUCRE	4.	Height (mm)
	5.	Width (mm)[a]
PHYLLARIES:	6.	Outer phyllary planation: 1, flat; 2, cupped; 3, keeled[a]
	7.	Inner phyllary length (mm)
	8.	Inner phyllary width (mm)
	9.	Inner phyllary shape index: [length (mm) - distance from apex to point of greatest width]/ length (mm)[a]
	10.	Inner phyllary apex shape: 1, truncate; 2, obtuse; 3, acute; 4, acuminate
	11.	Inner phyllary apex reflexion: 1, none; 2, weak; 3, strong
	12.	Inner phyllary apex planation: 1, flat; 2, involute[a]
	13.	Extent of scarious margin on inner phyllary: 1, basal 2/3; 2, basal 2/3 but not around apex; 3, complete
FLOWERS:	14.	Number/head[a]
	15.	Corolla tube length (mm)
	16.	Pappus length (mm)
PUBESCENCE:	17.	Density on petioles, inflorescence bracts, and phyllaries: (Density was assessed on each part and the three assessments summed.): Character states for individual parts were 0, glabrous; 1, sparse; 2, moderate; 3, dense

[a]Included in data sets C and E.

TABLE 3. Character loadings with absolute values greater than 0.5 for the first two principal component axes.

Data Set	PCA Axis	Character	Loading
A	I	no. heads/3 cm	0.670
		involucre height	-0.736
		involucre width	-0.738
		phyllary length	-0.820
		corolla length	-0.805
		pappus length	-0.811
	II	inner phyllary apex shape	0.754
		extent scarious margin on phyllary	-0.604
B	I	no. heads/3 cm	-0.761
		involucre width	0.690
		inner phyllary apex shape	-0.691
		inner phyllary reflexion	-0.519
		no flowers/head	0.788
		outer phyllary planation	-0.722
		inner phyllary planation	-0.749
	II	Involucre height	0.683
		phyllary length	0.868
		corolla length	0.767
		pappus length	0.797
C	I	no. heads/3 cm	-0.782
		involucre width	0.742
		inner phyllary apex shape	-0.626
		no. flowers/head	0.843
		outer phyllary planation	-0.745
		inner phyllary planation	-0.779
	II	involucre width	0.506
		inner phyllary apex shape	0.662

specimens, material of these geographical ranges constituted two phases of the distribution of OTU's in two-dimensional space. PCA scores for the five outgroup OTU's were discontinuous with the body of scores for the 41 other OTU's.

LIATRIS REGIMONTIS TYPE SPECIMENS - SANDHILLS PLANT COMPARISON — The univariate comparison of the type specimens of *Liatris regimontis* with specimens of the sandhills plant suggested a morphological distinction between the two (Table 4).

LIATRIS GRAMINIFOLIA VAR. SMALLII - SANDHILLS PLANT COMPARISON — The first axis of the PCA performed on data set B explained 26.0% of the data variation. Characters loading heavily on this axis pertained to head size and density in the inflorescence and phyllary shape (Table 3). The

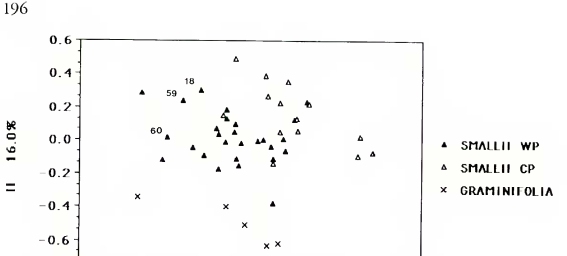

FIG. 1. PCA of data set A showing PCA scores of OTU's on axes I and II. OTU 18 = isotype of *Liatris regimontis* (Small) K. Sch.; 59 = holotype of *L. regimontis*; 60 = holotype of *L. graminifolia* var. *smallii*. (Britt.) Fern. & Grisc. WP = Western Piedmont; CP = Coastal Plain.

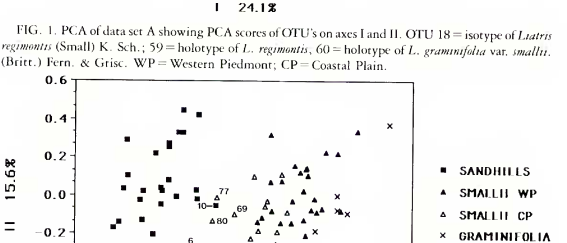

FIG. 2. PCA of data set B showing PCA scores of OTU's on axes I and II. Numbered OTU's are interpreted as intermediate between the sandhills plant and *Liatris graminifolia* var. *smallii*. OTU's are identified in Table 1. WP = Western Piedmont; CP = Coastal Plain.

second axis explained 15.6% of the data variation and was interpreted primarily as a head and flower length axis (Table 3). A discontinuity between the PCA scores for the sandhills plant and those for *Liatris graminifolia* var. *smallii* and the types of *L. regimontis* was evident along the first axis (Fig. 2). This discontinuity was greater than that between *L. graminifolia* var. *smallii* and the outgroup OTU's. This discontinuity was broached somewhat by two disparate specimens of the sandhills plant from

Table 4. Comparison of the holotype and isotype of *Liatris regimontis* with the sandhills plant.

Character	*Liatris regimontis*	Sandhills plant
Inflorescence	heads frequently widely spaced along inflorescence axis; not secund	heads closely spaced along inflorescence axis; frequently secund
Involucre shape	obconic	narrowly obconic
Inner phyllary apex	acute, not involute	acute to acuminate, involute
Outer phyllaries	cupped	strongly cupped to keeled
Flowers/head	9 – 12	4 – 9 (10)

Robeson (OTU 10) and Hoke (6) counties, NC, and three specimens of *L. graminifolia* var. *smallii* from Charleston (80), Florence (69), and Williamsburg (77) counties, SC.

The first axis of the PCA performed on data set C explained 57.1% of the data variation. Characters loading heavily on this axis pertained to head size and density and phyllary shape (Table 3). The second axis explained 15.6% of the variation and was interpreted as a phyllary shape and head size axis (Table 3). The discontinuity between the sandhills plant and *Liatris graminifolia* var. *smallii* plus the types of *L. regimontis* along axis one was approximately equal to that between the latter taxon and the outgroup OTU's (Fig. 3). The sandhills specimen from Robeson (OTU 10) County, NC, and the specimens of *L. graminifolia* var. *smallii* from Charleston (80), Florence (69), and Williamsburg (77) counties, SC, were, again, intermediate.

The cluster analysis performed on data set B indicated two major clusters; one composed of 24 sandhills plant OTU's and the other composed of 39 *Liatris graminifolia* var. *smallii* OTU's from both Piedmont and Coastal Plain sites including the holotype, the two type specimens of *L. regimontis*, the five outgroup OTU's, and one sandhills plant OTU (Fig. 4). The cluster analysis on data set C also indicated two major clusters; one comprised entirely of *L. graminifolia* var. *smallii* and outgroup OTU's and the other comprised of 25 sandhill plant OTU's plus three OTU's of *L. graminifolia* var. *smallii* from Coastal Plains sites (Fig. 5). Cluster analyses that utilized chord distances agreed closely with those presented here; the primary differences being the distances at which OTU's clustered with each other.

Of the nine specimens that initially appeared morphologically intermediate, specimens from Bladen (OTU's 23, 25) and Columbus (22)

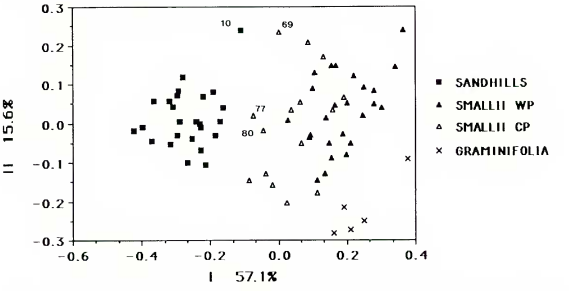

FIG. 3. PCA of data set C showing PCA scores of OTU's on axes I and II. Numbered OTU's are interpreted as intermediate between the sandhills plant and *Liatris graminifolia* var. *smallii*. OTU's are identified in Table 1. WP = Western Piedmont; CP = Coastal Plain.

counties, NC, and Horry (24) County, SC, were shown to be intermediate by PCA (Figs. 6 and 7). The specimens from Robeson (26) and Cumberland (20) County, NC, could, possibly, also be interpreted as intermediate. PCA indicated that the specimens from Johnston (11) and Wayne (19) counties, NC, were compatible with *L. graminifolia* var. *smallii*. The specimen from Williamsburg (77) County, SC, not initially felt to be intermediate and initially annotated as *L. graminifolia* var. *smallii*, was also intermediate according to PCA. Additional initially annotated specimens that could, possibly, be interpreted as intermediate include those from Florence (69) and Charleston (80) counties, SC.

DISCUSSION

LIATRIS REGIMONTIS - L. GRAMINIFOLIA VAR. SMALLII COMPARISON — The PCA showed that the type specimens of *Liatris regimontis* were reasonably congruent with the holotype of *L. graminifolia* var. *smallii* and that all three types were included within the range of variability collectively exhibited by the 38 other specimens of *L. graminifolia* var. *smallii*. These results suggested that *L. graminifolia* var. *smallii* and *L. regimontis* refer to the same plants. The use of specimens determined as *L. graminifolia* var. *smallii* in this study of the circumscription of *L. regimontis* was justified.

Although the Coastal Plain collections of *Liatris graminifolia* var. *smallii* appeared to be somewhat differentiated from the western Piedmont collections, these two aspects formed one continuum of variation. We recommend that these two regional elements not be taxonomically distinguished

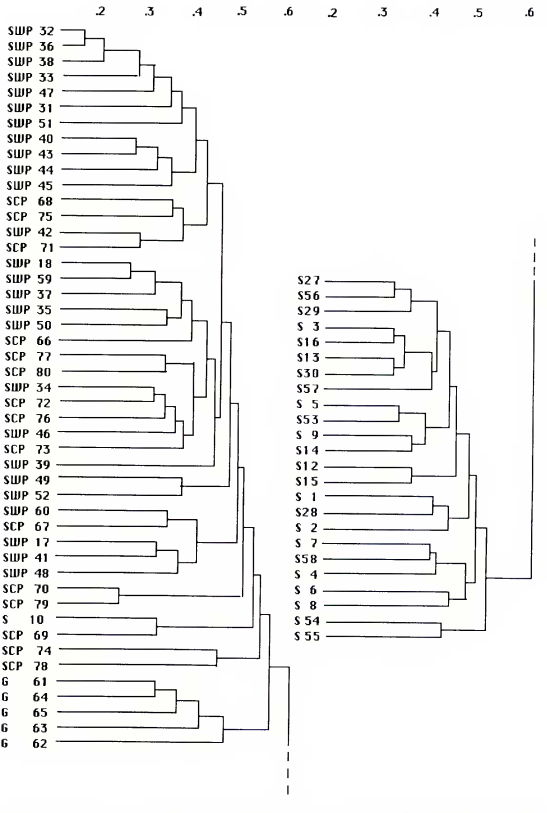

FIG. 4. Phenogram of cluster analysis of data set B. SWP = var. *smallii* of Western Piedmont; SCP = var. *smallii* of Coastal Plain; S = sandhills plant; G = var. *graminifolia* (outgroup). OTU's are identified in Table 1.

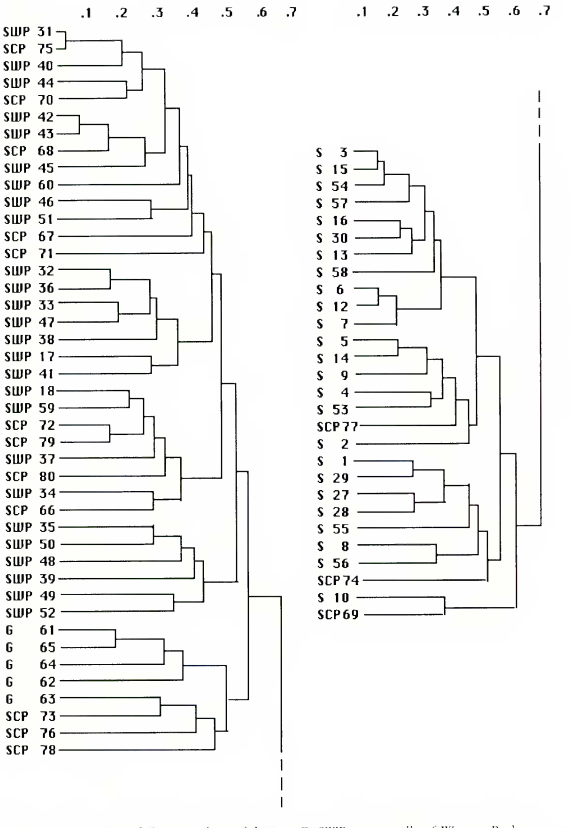

FIG. 5. Phenogram of cluster analysis of data set C. SWP = var. *smallii* of Western Piedmont; SCP = var. *smallii* of Coastal Plain; S = sandhills plant; G = var. *graminifolia* (outgroup). OTU's are identified in Table 1.

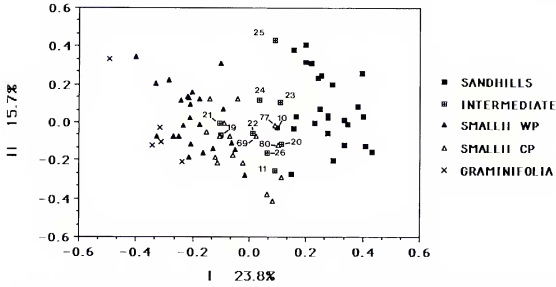

FIG. 6. PCA of data set D showing PCA scores of OTU's on axes I and II. OTU's are identified in Table 1. Intermediate = OTU's initially determined as intermediate between *Liatris graminifolia* var. *smallii* and the sandhills plant; WP = Western Piedmont; CP = Coastal Plain.

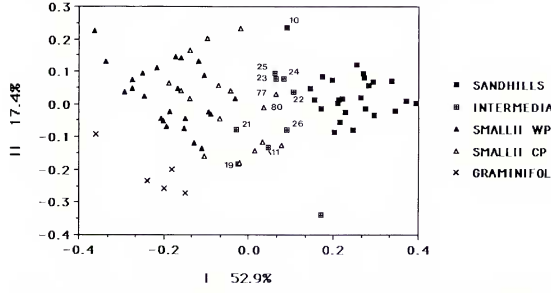

FIG. 7. PCA of data set E showing PCA scores of OTU's on axes I and II. OTU's are identified in Table 1. Intermediate = OTU's initially determined as intermediate between *Liatris graminifolia* var. *smallii* and the sandhills plant; WP = Western Piedmont; CP = Coastal Plain.

at this time and that future study of the relationships between the two is needed. Additionally, study of the distinction between *L. graminifolia* var. *smallii* and *L. graminifolia* var. *graminifolia* is warranted to determine if the former would most appropriately be recognized as a variety or as a species, *L. regimontis* (Small) Schumann.

Liatris regimontis TYPE SPECIMENS - SANDHILLS PLANT COMPARISON — Each character suggested a morphological discontinuity between

the types of *Liatris regimontis* and the sandhills plant. Distinguishing the different involucre shapes and the cupped vs. keeled nature of the outer phyllaries exhibited by the two groups was strongly subjective. The characters that most objectively distinguished the two groups were the spacing of heads along the inflorescence axis, involute vs. non-involute nature of inner phyllary apices (Figs. 8 and 9) and number of flowers/head.

LIATRIS GRAMINIFOLIA VAR. SMALLII - SANDHILLS PLANT COMPARISON — The distinction between *Liatris graminifolia* var. *smallii* and the sandhills plant was equal to or greater than that between *L. graminifolia* var. *smallii* and the outgroup OTU's representing *L. graminifolia* var. *graminifolia*, according to the two PCA's. This distinction was also indicated by

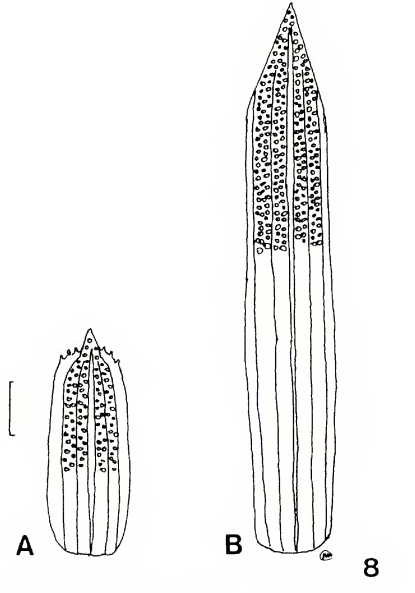

FIG. 8. An outer (A) and an inner (B) phyllary of the sandhills plant. Bar = 1mm.

the two cluster analyses. According to PCA, specimens from a continuous north-south geographical zone from Cumberland County, NC, to Williamsburg County, SC, were morphologically intermediate between *L. graminifolia* var. *smallii* and the sandhills plant (Fig. 10). All specimens which initially appeared intermediate prior to the analyses were included in the final PCA while only a sampling of those specimens that appeared typical for the sandhills plant and *L. graminifolia* var. *smallii* were included. In view of this "heavy sampling" of potential intermediates, it is our opinion that the relatively few OTU's that were shown by the numerical analyses to be truly intermediate do not obviate the overall discontinuity between the sandhills plant and *L. graminifolia* var. *smallii*.

Both PCA and cluster analyses suggested that the affinity of the sandhills plant is stronger with the Coastal Plain aspect of *Liatris graminifolia* var. *smallii* than with the western Piedmont aspect. If Gaiser (1946) was correct in suggesting that the widely distributed, morphologically variable *L. graminifolia* is the evolutionary ancestor to the other geographically more restricted, less variable taxa in series Graminifoliae, the results of the current study suggested that the sandhills taxon evolved from ances-

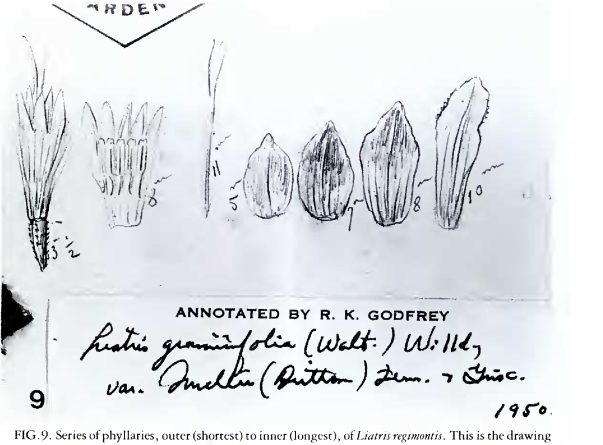

FIG. 9. Series of phyllaries, outer (shortest) to inner (longest), of *Liatris regimontis*. This is the drawing that is on the holotype of *L. regimontis* (Small) Schumann.

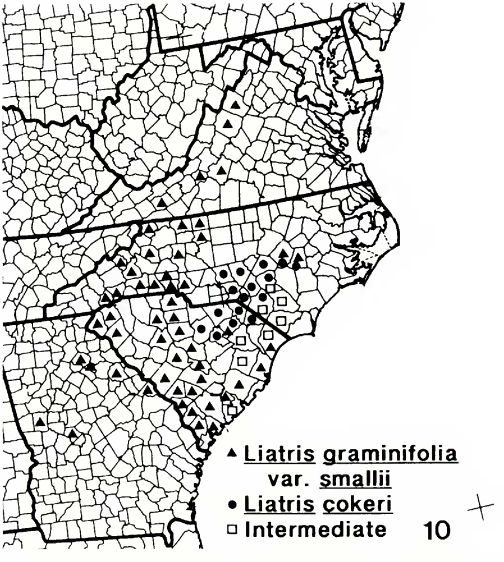

FIG. 10. Distributions of *Liatris cokeri*, *L. graminifolia* var. *smallii*, and intermediates between the two taxa.

tral *L. graminifolia* populations of the Coastal Plain. The current study does not provide an adequate basis for determining if the more likely ancestor is *L. graminifolia* var. *smallii* or *L. graminifolia* var. *graminifolia*, the latter variety common in the Coastal Plain of North Carolina, because so few specimens of the latter variety were included in the analyses. Investigations of the relationships of the sandhills plant with the two varieties are warranted. The intermediate specimens could indicate a zone of primary intergradation between the sandhills plant and its ancestral Coastal Plain populations (Fig. 10) or they could indicate hybridization between differentiated populations.

Our results show that the sandhills plant should be recognized as a

species since it is morphologically distinct from plants representative of a species concept in which it has previously been included. We are not the first to recommend its taxonomic recognition. The label of an R. K. Godfrey collection of the sandhills plant (*Godfrey 50098*, Moore Co.: NC, 15 Sep 1949) states, "This is considered by Gaiser to be *L. regimontis* (Small) Schumann, but is considered by the collector to be an entirely different taxon." Godfrey annotated this and other specimens (NCSC) as *Liatris carinata* (Small) Coker. *Laciniaria carinata* Small (1903), the basionym of *Liatris carinata* (Small) Coker, has been lectotypified to a specimen of *Liatris secunda* Ell. (1822); therefore, *Liatris carinata* (Small) Coker is a synonym for *L. secunda* Ell. and is not available for the sandhills taxon (Pyne and Stucky 1990). A name for the sandhills species must be published.

NEW SPECIES OF *LIATRIS*

1. LIATRIS COKERI Pyne & Stucky, sp. nov.

Species nova similiter *L. regimontis* (Small) Schumann optimo distinguitur a capitulis approximatioribus, apices phyllariis intimis involutis, floribus paucioribus per capitulo. Species nova similiter *L. secunda* Ell. optimo distinguitur a caule glabrate, phyllariis carinatis, patenibus ad reflexis, involucro paulo brevior et corolla et pappo multo brevior.

Perennial herb; rootstock corm-like, globose, 0.8 − 3.0 cm wide. Stems 1 − 5 per corm, usually unbranched, frequently drooping or upright, glabrous, usually sparsely minutely glandular, 25 − 85 cm tall. Leaves linear, densely punctate on both surfaces, occasionally sparsely hirsute along midvein on either or both surfaces, margins irregularly ciliate near base or occasionally glabrous, (1.8) 2.0 − 4.8 (5.0) mm wide × 0.5 − 1.8 (2.0) dm long, length gradually reduced upwards. Inflorescence a spike or compact raceme; heads imbricate along rachis, frequently secund, sessile or on bracteate peduncles to 6.0 mm long, closely ascending or diverging particularly when heads secund. Involucres narrowly obconic, 4.8 − 10.5 mm long × 4.0 − 7.8 (8.0) mm wide at tips of phyllaries during anthesis; phyllaries imbricate in several series, punctate, scarious-margined, usually minutely ciliate or occasionally glabrous; inner phyllaries strongly acute to acuminate, apically involute and spreading to reflexed, 5.0 − 8.8 (9.0) mm long; outer phyllaries acute, strongly cupped to keeled. Flowers 4 − 9 (10) per head, corolla tube pink, glandular outside, pilose basally inside, 4.2 − 7.0 (7.5) mm long. Pappus barbellate, 4.0 − 7.0 mm long. Mature achenes obconic, 2.7 − 3.8 mm long, 0.8 − 1.2 mm wide at apex, angular in cross section, longitudinally ribbed, densely hirsute with ascending trichomes, gray to black.

TYPE: NORTH CAROLINA. Harnett Co.: 0.2 mi E jct. NC rt. 27 and co. rt. 1242 along NC 27 on S side road; sandy roadside and margin of longleaf pine/turkey oak/

wiregrass vegetation; 23 Sep 1989, *J.M. Stucky 511* (HOLOTYPE: NCU; ISOTYPES; GH, NCSC, NCU, NY, US, USCH).

This species is named in recognition of Dr. W. C. Coker who contributed significantly to the botany of the Carolinas and who included this species, calling it *Liatris carinata* (Small) Coker, in *The Plant Life of Hartsville, S.C.* (1912). Although the resolution of a lectotypification problem makes his combination incorrect for this species (Pyne and Stucky 1990), Dr. Coker should be recognized. As far as can be determined, the only vascular plant presently bearing the epithet *cokeri* is *Lycopus cokeri* Ahles.

As stems of *Liatris cokeri* grow longer and as heads mature and become heavier, the degree of drooping of the stems usually increases. On these drooping stems, the heads respond phototropically, causing the secund nature of the inflorescence. Due to its phenological basis, the secund inflorescence becomes more prevalent as the growing season progresses. The non-secund nature of an inflorescence should carry little diagnostic significance, particularly for specimens collected early in the growing season.

Liatris cokeri and *L. secunda* Ell. frequently form mixed populations in the Fall-line sandhills of the Carolinas and thus the species have often been confused. The basis of this confusion undoubtedly is their shared habitat and the secund inflorescence. Several characters do, however, distinguish *L. cokeri* from *L. secunda* in this area (Table 5).

KEY TO SPECIES OF *LIATRIS* OF THE CAROLINA FALL-LINE SANDHILLS AND ADJACENT OUTER COASTAL PLAIN

1. Pappus plumose ..... *L. squarrosa*
1. Pappus barbellate 2
   2. Middle and/or outer phyllaries squarrose; heads tending to be turned away from the axis, not secund ..... *L. earlei*

TABLE 5. Distinctions between *Liatris cokeri* and *L. secunda*.

Character	*Liatris cokeri*	*Liatris secunda*
Stem pubescence	Lacking	Usually densely, minutely, hirsute basally
Involucre length	4.8–10.5 mm	8.8–12.2 mm
Phyllary keeling and reflexion	Outer frequently distinctly keeled; spreading to reflexed	Outer weakly keeled; appressed or barely spreading
Corolla tube length	4.2–7.0 (7.5) mm	7.8–9.0 mm
Inner corolla tube pubescence	Evident basally	Lacking or sparse
Corolla lobe length	1.5–3.0 mm	3.0–5.0 mm

2. Phyllaries appressed or spreading, not squarrose; heads ascending or, if turned away from the axis, secund 3
3. Inner corolla tube glabrous or nearly so 4
3. Inner corolla tube evidently hairy toward base 6
4. Inflorescence secund; involucre 8.8 – 12.2mm long; stem usually densely short pubescent basally, occasionally glabrous . . . . . *L. secunda*
4. Inflorescence not secund; involucre 5.8 – 11.5mm long; stem glabrous or nearly so 5
5. Heads sessile; basal leaves >3.5mm wide . . . . . *L. spicata*
5. Heads pedicellate; basal leaves <3.5mm wide . . . . . *L. tenuifolia*
6. Inner phyllaries acute to acuminate, more or less spreading 7
6. Inner phyllaries obtuse to acute, appressed . . . . . *L. graminifolia* var. *graminifolia*
7. Inner phyllary apices involute; flowers 4 – 10 per head . . . . . *L. cokeri*
7. Inner phyllary apices not involute; flowers 8 – 12 per head . . . . . *L. graminifolia* var. *smallii*

Liatris earlei (Greene) Schumann and *L. secunda* Elliott, recognized by Ahles (in Radford et al. 1968) are listed in synonymy under *L. squarrulosa* Michaux and *L. pauciflora* Pursh, respectively, by Cronquist (1980).

ACKNOWLEDGEMENTS

The authors thank the curators of GH, NCSC, NCU, NY, and USCH for making specimens available; the North Carolina Wildflower Protection Society for financial assistance; Dr. James Reynolds for modifying and making available computer programs; Dr. Paul Fantz for assistance with the Latin diagnosis, Drs. Robert Godfrey and John Pruski for guidance, and Drs. Jimmy Massey, Robert Wilbur, and Paul Fantz for manuscript reviews.

REFERENCES

COKER, W. C. 1912. The plant life of Hartsville, S. C. The Pee Dee Hist. Assoc. Columbia.

CRONQUIST, A. J. 1952. Compositae, In H. A. Gleason. The new Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. Vol. 3. New York Bot. Gard.

_____. 1963. Compositae, In H. A. Gleason and A. E. Cronquist. Manual of the vascular plants of the northeastern United States and adjacent Canada. Vol. 3. New York Bot. Gard.

_____. 1980. Vascular flora of the southeastern United States. Vol. I, Asteraceae. Univ. of N.C. Press. Chapel Hill.

DUKE, J. A. 1961. The psammophytes of the Carolina fall-line sandhills. J. Elisha Mitchell Sci. Soc. 77:3 – 25.

ELLIOTT, S. 1822. Sketch Bot. S. Carolina. 2:278.

FERNALD, M. L. 1950. Gray's manual of botany, 8th ed. American Book Co. New York.

GAISER, L. O. 1946. The genus *Liatris*. Rhodora 48:165 – 412 (pagination interrupted).

GODFREY, R. K. 1948. Studies in compositae of North Carolina, I: *Liatris*. J. Elisha Mitchell Sci. Soc. 64:241 – 249.

GOWER, J. C. 1971. A general coefficient of similarity and some of its properties. Biometrics 27:857–871.

PIELOU, E. C. 1984. The interpretation of ecological data. Wiley. New York.

PYNE, M. and J. M. STUCKY. 1990. Lectorypification of *Laciniaria carinata* (Asteraceae). Sida 14:209–213. 1990.

RADFORD, A. E., H. E. AHLES, and C. R. BELL, 1968. Manual of the vascular flora of the Carolinas. Univ. of N.C. Press. Chapel Hill. (*Liatris* treatment by H. E. Ahles)

SMALL, J. K. 1898. Studies in the botany of the southeastern United States. Bull. Torrey Bot. Club 25:473.

———. 1903. Flora of the southeastern United States. Published by the author. New York.

———. 1933. Manual of the southeastern flora. Published by the author. New York.

SNEATH, P. H. A. and R. R. SOKAL. 1973. Numerical taxonomy. The principles and practice of numerical classifications. W. H. Freeman. San Francisco.